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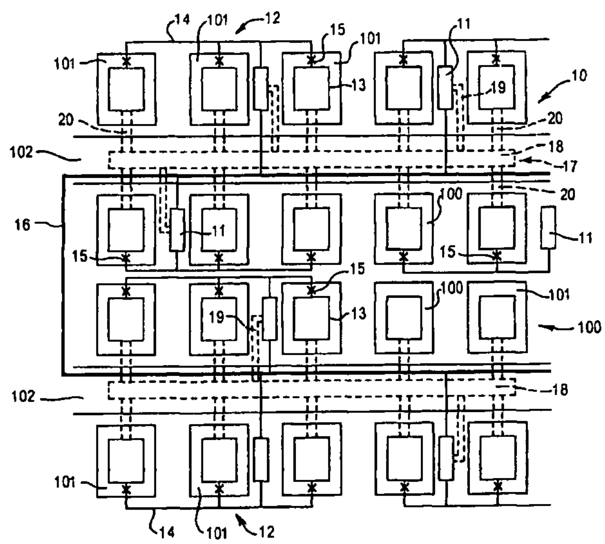

(57) Abstract: A system (10) for the generation and distribution of energy to a region (100) includes a plurality of embedded generators (11). Each generator is operative to produce both electrical energy and thermal energy. The region (100) is formed of a plurality of sub-regions with the system including a plurality of first energy distribution systems (12) to distribute energy to a respective one of the sub-regions, and a second energy distribution system (16) which is operative to distribute energy to the first distribution systems. Electrical loads (50) and thermal loads (51) for each sub-region is monitored and transmitted to a local controller (17) associated with the respective generators (11). The local data is then transferred in real time to a global controller where it is used to control the generators in an efficient manner.

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DECENTRALISED ENERGY NETWORK SYSTEM

The present invention relates generally to a system and method for the generation and distribution of energy. The invention has been designed especially, but not exclusively, for the generation of electricity and is herein described in that context. However, it is to be appreciated that the invention has broader application and may be used in fulfilling other energy requirements, such as thermal loads, and is therefore not limited to that particular use.

Traditional electrical power is provided by electrical utilities over a wide area power grid. The grid includes at least one centrally based power station and a network of transmission and distribution lines to distribute the electricity to widely dispersed sites where it is used.

Numerous problems are associated with the traditional power grid. In particular, the power grid is not efficient as there are significant energy losses throughout the system, particularly in the transmission and distribution of electrical energy over a large area and the lack of realistic opportunity to utilise the heat by-product from central power generation plants. Further, it is often difficult to extend the power grid to new areas as this requires substantial infrastructure costs, not only for equipment but also for acquiring use of land to install the transmission lines and additional power stations if required. A traditional power grid is also often inflexible to changing load requirements and is often susceptible to outages because of its fundamental architecture.

An aim of the present invention is to provide an alternative energy system which ameliorates the above problems and which is more flexible and efficient.

Accordingly, in a first aspect, the present invention provides a system for the generation and distribution of energy to a region, said region being formed of a plurality of sub-regions, and wherein the system includes a plurality of first energy distribution systems to distribute energy to respective ones of the sub-regions, a second energy distribution system to distribute energy to the first energy distribution systems, and a plurality of generators each associated with a respective one of the first distribution systems and the second distribution system so that each generator is able to supply energy both to its first distribution system and to the second distribution system.

In accordance with the present invention, an energy system is provided which is embedded in the region where the energy is required rather than located remote from that region. This is achieved through the use of a plurality of energy generators which are distributed through the region and which supply the region through the first and second distribution systems.

The system according to the present invention has advantages both in respect of the ease of installation of the system and its performance, particularly in relation to its reliability and efficiency. Previously, a significant cost in the installation of electrical services to a site related to the land costs for location of the transmission lines and/or any required power stations. In the present invention these costs may be obviated by the use of small generators which can be installed on-site, such as in the grounds of a commercial, industrial or domestic site. Further, there is no requirement for high voltage transmission lines and associated step-up and step-down transformers as the energy is generated at the appropriate voltage levels for use on site. The system is also more reliable as the failure of one generator does not cause an outage in the whole system as the loading can be taken up by the other generators. Further, the system may be more efficient as it does not incur the large transmission and distribution losses which are present in traditional energy grid systems.

In a preferred form, the system further includes control means which are operative to control the energy supplied by each generator to its respective first distribution system and the second distribution system. In a particularly preferred form, the system further includes monitoring means which are operative to establish in real time the energy load demand in each of the first distribution means and wherein the control means is operative to control the generators in response to the plurality of energy load demands established by the monitoring means.

The advantage of incorporating monitoring means within the system is that it enables an accurate load profile to be generated for the entire region. This load profile provides more sensitive feedback to the control means on the "localised" load profiles within the region and therefore enables the control means to more precisely distribute the load within that region where required

through its controlling of the individual generators within that region. This enables optional utilisation of the generators.

The size of each generator may vary depending on the application of the system. In one form, each generator has an electrical output of less than 20 kW and, more preferably, less than 10 kW. Generators of this size are ideally suited for use in residential areas where each sub-region constitutes typically two or three houses.

Preferably, the generators are powered by either a mains supply of natural gas or through a stored LPG supply. In that arrangement, the generators may include a gas engine or, alternatively, other forms of generators such as fuel cells may be used.

In a particularly preferred form, the electrical generators act as cogenerators which produce both electrical energy and thermal energy. In this arrangement, the thermal energy is recovered from heat given off by the generator. This waste heat is recovered and used for air conditioning and heating requirements. The use of the cogenerators is ideally suited for the system as the recovered heat can be used directly for the air conditioning and heating requirements in the region.

In one form, the recovered heat energy of a generator is operative to be used solely in the sub-region to which the generator is connected. In an alternative form, however, the recovered heat energy may be distributed by means of a thermal distribution system which interconnects the sub-regions. This thermal distribution system includes a series of interconnecting pipes and may also include reservoirs which act as a buffer to allow short term loading of air conditioners and heaters to be quickly supplied with the heat energy.

In a preferred form, the monitoring means is operative to establish both the electrical and thermal load demands in the individual sub-regions. Preferably these load profiles are passed to the control means which then control the operation of the generators to fulfil the thermal and electric load demand in the most efficient manner. For example, if a first sub-region has a low electrical demand but a high thermal load demand, whereas a second sub-region has a low thermal load demand and a high electrical demand, the control

means is able to recognise this arrangement and responds accordingly by operating the generator in the first sub-region to meet the required thermal load in that region and use the excess electricity to meet the demand for electricity in the second sub-region. Under this scenario, the generator in the second sub-region, even through there is an electrical load demand, would not be utilised.

In a densely populated area, preferably a proportion of the households or businesses have a generator installed. A determination of how many generators are required to service each community is calculated by the size of the generator and the climactic demand for electricity and use of recovered heat for air conditioning and heating requirements and the like. In a typical arrangement, a city having a temperate climate may incorporate a generator in about one in every two to three houses.

In this arrangement, the sub-region corresponds to those residents which are in the immediate vicinity of the generator or to individual houses within that immediate vicinity. The division of the sub-regions which is established by the size of the respective first distribution systems may easily be altered depending on their location and switching systems which may be embedded in the system.

In one form, the generators within a region are the sole supplier of energy to that region. In another form, energy may also be supplied through that region through the second distribution means from a remote large power supply, or from generators from another region. Further, each generator may operate in isolation to service a particular sub-region or may be operated in parallel to form a local cluster.

Further, in a preferred form, each generator is able to operate in a stand-alone mode where it provides electrical energy solely to it's sub-region through it's first distribution system, or in a network situation where energy can be imported to the sub-region or the generator can export energy through the second distribution system. When in a networked situation, the individual generators are connected in parallel and therefore operate as a regional cluster. Switching arrangements are operative to isolate the generators from the second distribution system so as to enable the generators to operate in either

stand-alone or networked mode. Further, engine management systems are provided to vary the output from the engine to enable load sharing throughout a cluster or to allow exporting of power to a mains grid if available. Preferably these switching arrangements and the engine management systems are controlled under operation of the control means.

A main benefit of this arrangement is that it substantially improves the reliability of the system and minimises the chances of power failure occurring. For example, if one generator fails, its load demand in its associated sub-region can be carried by the other generators. Alternatively, if there is a break in the second distribution system, each generator is able to operate in stand-alone mode and maintain power to its individual sub-region.

In one form, the generators include a gas engine which is designed solely to operate at an optimum level to thereby improve the efficiency of the overall energy system. In this arrangement, rather than have each engine being able to operate at varying speeds, when a generator is brought on line, it is designed to run substantially solely at its optimum speed. When the load demand changes, a greater or lesser number of generators are brought on line. As the electrical output of the generators is relatively low (preferably less than 10 kW) the system is able to closely match the load demand throughout the region. Therefore the system is able to sense and immediately react to changing energy load profiles, optimising the number and power output of the small generators that need to be run at any given time and maximising the overall efficiency.

In a preferred form, the second distribution system is in the form of a low voltage ring main cable which is typically laid underground throughout the region. With this arrangement, the entire electrical system can be concealed. There is no need for any overhead wires or cables.

In a preferred form, the generators remain under the ownership of a utility which is in charge of the supply or generation of energy. In that arrangement, the utility then sells the energy produced to the individual consumers. Typically under this arrangement, each generator is installed and serviced at no upfront cost to the consumer.

Preferably each generator includes a control module which is operative to communicate with other generators in the region. This allows the sharing of data such as operational status and load demand between the individual units and also provides means for controlling the system. The control modules also carry all the billing data obtained from each generator. In one form, the generators are arranged in clusters with the units in each cluster operative to communicate information to other generators in the cluster. This may be via any suitable means such as conventional telephone lines, cellular diallers, cable, satellite or the like. At least one generator within the cluster acts as the master unit and includes cellular or satellite communication with a host unit. The host unit, which is typically controlled by the utility, coordinates all billing data and also processes the accumulated information from the individual units to allow the most economical mode of operation of the system. An advantage of the present invention is that the system is not prone to produce a widespread power failure should part of the communication system break down. For example, the master units within a cluster can assume the host function if communication to the host is not available. Similarly the units can operate in a stand-alone mode should any one master unit fail.

In a further preferred form, the energy system of one region may be linked to a corresponding energy system in another region. The communication between the energy systems of respective regions can be coordinated through the utility host and a further third distribution means is incorporated to allow the transmission of energy between regions.

The size of any one region may vary depending on the particular situation. For example, a region may comprise a suburb of a city, a remote village or even an island. In a preferred form, the only requirement to provide the energy to the region is a supply of gas which may be via mains supply or alternatively from a stored LPG supply. In accordance with the system of the invention, energy can be provided within a framework that is flexible, reliable and efficient.

In a further aspect, the present invention provides a method of generating and supplying energy to a region, said region being formed of a plurality of sub-regions, the method including the steps of:

(i) providing a plurality of generators in said region, the generators being operative to supply electrical energy to each sub-region,

(ii) obtaining load data in real time on the energy load demand in each of the sub-regions, and

(iii) controlling the operation of said generators based on the plurality of load demand profiles of the sub-regions.

It is convenient to hereinafter describe an embodiment of the present invention with reference to the accompanying drawings. It is to be appreciated that the particularity of the description is to be understood as not superseding the generality of the preceding broad description of the invention.

In the drawings:

Figure 1 is a schematic illustration of a region including the energy system;

Figure 2 is a functional block diagram of a GES unit installed as part of the energy system; and

Figure 3 is a schematic block diagram of a communication system of the energy system of Figure 1.

Turning firstly to Figure 1, an embedded energy network system 10 is disclosed which is operative to supply electricity and thermal energy to a region 100. In the illustrated form, the region is a suburban area made up of individual dwellings 101. For ease of reference, only a small part of the region is shown. Typically the region would entail hundreds, if not thousands, of dwellings although the actual number is not critical due to the "modular" nature of the system 10 as will be discussed in more detail below. It is to be appreciated that the system 10 is also applicable to other types of areas such as industrial, commercial or the like.

The system 10 includes a plurality of GES units (General Energy System Unit) 11 which are embedded in the region and operative to supply both electrical and thermal energy to the region 100. The GES unit acts as a

cogenerator to produce electricity using a fuel supply, which is typically a mains supply of natural gas or stored LPG gas, with the excess heat generated being recovered to be used to meet thermal load demands for space conditioning (both heating and cooling), hot water, refrigeration and the like.

These GES units 11 are installed within the properties of selected houses. In the Figures, each GES unit 11 services three adjacent houses, although the proportion of GES units which are required to service a region will depend on the size of the generator and the climactic demand for electricity and the use of recovered heat. Accordingly, it is to be appreciated that this may vary.

Each GES unit 11 is connected to a first distribution system 12 which is operative to supply electricity from that unit to the houses with which it is associated. In the illustrated form, each first distribution system comprises the house wiring 13 of the individual dwellings 101 and a common line 14 which connects to the GES unit 11. The first distribution system 12 also includes metering devices 15 to enable load data to be provided from each of the houses for the purposes of billing. In this way, each of the first distribution means defines a sub-region of the area which is serviced by the energy system 10.

The system 10 also includes a secondary distribution system 16 which interconnects each of the GES units 11 in parallel to thereby form a regional cluster that enable electricity to be distributed throughout the sub-regions. Specifically it allows a GES unit from one sub-region to supply electricity to another sub-region if required. In the illustrated form, the second distribution system 16 is in the form of a low voltage (415/240 volts) ring main cable, which is laid underground. As the first distribution means is also typically laid underground, an advantage of the system 10 is that there is no requirement for overhead wires.

The system 10 also includes a thermal distribution system 17 which is operative to capture the recovered heat energy and distribute it throughout the region. In the illustrated form, the thermal distribution system 17 includes a series of separate reservoirs 18 which are installed under the road 102 of the region 100.

Input pipes 19 feed the recovered heat from the generators 11 into a respective one of the reservoirs 18. Outlet pipes 20 then extend from the reservoir 18 to the individual houses 101. In this way, the thermal distribution system 17 allows for storage of the recovered heat and distribution of that heat to the individual houses 101. In particular, the reservoirs 18 act as a buffer to allow short term thermal loads, such as derived from air conditioners and heaters to be quickly supplied with the recovered energy. This recovered energy may use an environmentally friendly treated water system in temperate climates to allow it to be distributed throughout the region.

Figure 2 illustrates a functional block diagram of a GES unit 11 installed as part of the energy system 10.

The GES unit includes an internal combustion gas engine 21. The engine is a high reliability long life power plant, specifically designed for waste-heat recovery (liquid-cooled block, and heat exchanger for exhaust heat recovery). The engine employed is a single-cylinder spark ignition unit with a maximum output of 3.75 kW at 3000 rpm. The energy source for the engine is by way of a gas input 22 which is natural gas or LPG. Shut off and safety interlocks are not shown, but are typically implemented to satisfy regulatory requirements.

A waste heat recovery unit 23 is included which delivers waste heat via a circulating coolant flow. The coolant flows through the engine 21 and the exhaust heater exchanger and is delivered to the external coolant loop where upon it gives up thermal energy and re-enters the engine 21 at a reduced temperature. A conventional wax pellet thermostat is used in the engine to ensure stable engine temperatures.

In the illustrated embodiment, a three-phase brushless alternator 24 is used to convert the engine power to electrical power. Alternatively, a permanent magnet alternator and solid state inverter combination can be used. The excitation of the alternator is controlled by a voltage regulator 25. The voltage regulator determines the appropriate level of alternator excitation whilst operating stand-alone, and also when in parallel with other GES units (such as via the second distribution system) or when connected to a mains. A quadrature

current droop method of voltage control is employed to obtain good reactive power sharing between machines. A closed-loop reactive power control method is used when in parallel with the second distribution system in order to keep reactive power flow to and from the network within acceptable limits.

The engine itself, and all engine ancillary items are controlled by a microcontroller based engine control system (ECS) 26. Control of the gas valves and all engine protection functions are also carried out by the ECS. The ECS 26 produces spark and throttle position command to control the engine. Fuelling and ignition are controlled in an optimal manner to provide the best possible fuel efficiency and emission performance. In the configuration where an alternator is used, the primary means of achieving the required performance are through spark timing, throttle control, and mixture tuning. In operation, the engine 21 is run at more or less constant speed at 3000 rpm with varying loads. There are two distinct control modes; droop, and constant power. These two modes are ultimately implemented by means of throttle control, but are quite different in function. In the droop mode, the engine speed "droops" depending on the magnitude of the electrical power delivery from the driven alternator 24 as fed to an ECS input from a power transducer. In the constant power mode, the engine speed is determined by the frequency (via the alternator) in a mains supply, and the engine power delivery is as requested by another input to the ECS. Further details of the engine control system both in the form described above where an alternator is used as well as in an arrangement where a permanent magnet generator and solid state inverter combination is used is described in the applicant's co-pending application entitled "Engine Management System", the contents of which are herein incorporated by cross-reference.

A programmable logic controller (PLC) 27 is provided to manage engine running, stopping and selection of the appropriate engine control mode (droop or constant power) as well as engine control, electrical synchronising and connection with the output electrical bus and electrical trips, are handled by the PLC 27. In addition, the monitored quantities of the electrical load 50 in the first distribution system 12 as well as the local thermal load 51 are brought into the

PLC 27, which are then able to be transmitted to a global controller 28 via an external data I/O connection 29 as described in more detail below.

The alternator 24 output is connected to an output bus 30 in a controlled manner via a contactor 31 with a mechanical isolator (for safety reasons). A synchronisation detector 32 ensures voltage and phase equivalence of the alternator 24 output and the output electrical bus (that is, either side of the switch 31) prior to initiating closure of the switch 31. Suitable frequency match is determined by the ECS 26, although this can also be done by other dedicated means of frequency monitoring. Once closed, the switch 31 stays closed, until requested by the PLC 27 to open (trip).

The electrical output bus 30 of the unit is the common bus of a given installation to which the load is connected via the first distribution means 12, and also the point to which the second distribution system 16 is also connected (in a controlled way). Therefore, an individual GES input is required to be able to connect to the electrical output bus whatever may be the present sharing this point of common connection. The PLC 27 can also enable connection to a dead bus should no other sources be present on it.

The second distribution system 16 provides a means by which the GES unit may be networked with other GES units to form a regional cluster. This network arrangement can interface with the GES unit in various different ways as described below. Whilst not shown, the second distribution system may in turn be connected to a remote mains supply if, for example, the regional cluster is designed to augment, rather than replace a mains supply to the region.

In the event that the second distribution system 16 is available and of "unlimited" delivery capacity, the second distribution system 16 is connected to the common bus 30, and whether the GES unit is put online at any one time is discretionary in terms of availability of electrical power to the load 50. However, typically, a governing factor may be the requirement for waste heat 51. If the waste heat requirement is high, the GES unit 11 may be put on line, and it will then supply electrical power and waste heat (this is the most economic use of the GES unit). Should the requirement for waste heat be low, the GES unit may not need to be put online. The global controller 28 can determine the local

waste heat requirement, via the PLC 27, and determine whether the GES unit is put online. The thermal load is typically monitored by heat meters that monitor the change in temperature and rate of flow of fluid in the thermal distribution system for each sub-region. In this configuration, if no mains is present, the delivery of networked GES units equals the load requirement in the region. If a mains supply is present, the net load on the second distribution system equals the delivery from the GES unit minus the load requirement, and the net import, export or a neutral condition with respect to the mains can be achieved.

In the event that the second distribution system is available but of "limited" delivery capacity, this external power is connected to the common bus 44, and whether the GES unit 11 is put online at any one time is determined primarily by the electrical requirements of the load (the GES unit runs in parallel with the other GES units in the cluster and augments the limited delivery capacity from the second distribution system). Furthermore, the decision whether the GES unit is required over this "essential" level can be governed by the requirement for waste heat 51. If the waste heat requirement is high, the GES unit can be put online, and then it will supply electrical power and waste heat (the most economic use of the GES unit). Should the requirement for waste heat be low, the GES unit may only be put online if essentially required. The global controller 28 can determine the electrical load requirement and knowing the limitation from the second distribution system and make an appropriate decision as to whether the GES unit be brought online. Also possible is a partial approach which consists of non-essential load shedding in the even that this is preferable to running the GES unit 11 without having sufficient use for the waste heat 51. In this configuration also, if a mains supply is present, the net load on the mains equals the GES unit delivery minus the load requirement, a net import, export or neutral condition with respect to the network power can be achieved. If no mains is connected then the delivery of the networked GES units equals the load requirement in the region.

In the event that the second distribution system 16 has failed, it is then isolated from the common bus 30, and the GES unit 11 will become online depending on the electrical requirements of the load 50, should the

requirements for waste heat be low, the global controller can decide to initiate non-essential load shedding, in the event that this is preferable to running the GES unit without having sufficient use for waste heat. In addition, load shedding is initially required down to the level that the GES unit can provide at the time the second distribution system 16 actually fails. The degree of initial load shedding depends on the output of the GES unit. Overall system control priority can be altered to suit loads which require reliable no-break power. Effectively, this is achieved by running the GES unit to supply the load 50 if the second distribution system 16 were to fail, and therefore placing a lesser importance on economic usage of waste heat. Once the GES unit is online, the load shedding can be scaled back to discretionary level. In this configuration, the GES unit delivery always equals the load requirement, and there is obviously no import or export with respect to the second distribution system.

In the event that the second distribution system returns, and can be reconnected to the common bus 30, without loss of continuity to the load and the situation reverts to either of the two situations indicated above.

A frequency drift method is employed to prevent back feed into the failed second distribution system 16, should the rare occurrence arise where conditions may make it possible for the GES unit to support "uncontrolled" loads in the system. In this instance, the system can determine that the second distribution system needs to be isolated, despite the "false" impression that it has not failed.

The second distribution system is connected or isolated from the common bus 30 by means of the solid-state contactor in concert with an conventional electro-mechanical contactor. The solid-state contactor provides for fast and clean disconnection of faltered main supplies with little disturbance to the common bus condition. The speed of the disconnection is such that no more than one cycle (20 ms) of outage is experienced on the common bus, even after "hard collapse" failure of the second distribution system. This duration is short enough to ensure ride-through of most commercial equipment (including PCs). The electro-mechanical contactor 33 provides galvanic isolation and maintenance security (in series with the solid-state contactor). Random

coincidence style of synchronising is employed upon return of the second distribution system, and the networked power is in again connected to the common bus 30 by means of the solid-state contactor.

A synchronisation detector 34 ensures voltage and phase equivalence of the network input 16 and the common bus 30 (that is; either side of the switch 33) prior to initiating closure of the switch 33. Suitable frequency and voltage match is also determined by the global controller 28 or separate PLC (not shown via transfusers). Once closed, the switch 33 stays closed, until requested by the global controller to open (trip).

The global controller 28 is the gateway to the individual GES units 11 and contains the software to control the overall system 10, including the waste heat distribution and load management.

The mode of operation of individual GES units 11 is dependent upon the network and the connection conditions. Prior to being connected to the common bus 30 the GES starts off in droop mode. If more than one GES unit in a regional cluster is to be started, a random coincidence style of synchronising is employed, and the individual unit 11 is then connected to the bus 30 by means of the contactor 31. Once connected to the common bus, the GES unit will either continue in droop mode if isolated or if the network connection via the second distribution means is made and no mains supply is present, or it will make a transition to constant power mode if a mains supply is connected to the common bus 30. In droop mode (no mains), the load on a given GES is dependant on the total electrical load, divided by the number of GES units online. In constant power mode, individual GES power delivery is determined by a command request from the global controller 28, however in both droop and constant power mode the GES delivery needs is to be kept at sensibly high levels in order that individual efficiency is not compromised due to under-loading.

The global controller 28 takes it's sensor and transducer inputs from the waste heat distribution system 17, as well as electrical transducer information from the first and second distribution systems, the common bus 30 and the

load 50. The individual GES unit pass information gathered locally to this global controller through the PLC 27 via the external data I/O connection.

The global controller 28 also contains the communication interface via a further external data I/O which allows connection as well as information exchange with the host computer as described in more detail below.

A main benefit of the arrangement of the energy system controller is that it substantially improves the reliability of the system as it minimises the chances of power failure occurring. For example, if one generator fails, its load demand in its associated sub-region can be carried by the other generators. Alternatively, if there is a break in the second distribution system 16, each generator is able to operate in a stand alone mode and provide power to its individual sub-regions. Further, the energy system is highly efficient not only because it uses its recovered heat energy, but also because as the energy is generated at site, transmission and distribution losses are significantly reduced.

The PLC 27 in each generator is operative to communicate with other generators in the region directly through the external data I/O connection 29 or via the global controller 28. This allows the sharing of data such as operational status and load demand between the individual units and also provides for means for controlling the system.

Figure 3 illustrates the communication system used in the energy system 10. The GES units 11 are arranged in clusters 36. The number of units 11 within any cluster 36 may vary but is typically in the order of one hundred generators within each cluster. The GES units 11 within each cluster 36 are operative to communicate information to other generators in that cluster. This may be via any suitable means such as cellular or land lines or the like and in the illustrated form is achieved through the external data I/O connections 29. At least one GES unit within the cluster acts as a master unit 37. This master unit 37 is in communication with a host 39 which is typically a services utility via a suitable communication system such as cellular or satellite systems. In this way, the host 39 is operative to issue instructions to the respective master units 37 within the individual clusters and, in turn, the master units 37 then issue instructions to the GES units 11 within that cluster.

Furthermore, the host 39 is able to receive data from each unit within the region 100 via the individual master units 37. This information includes the load profiles, both electrical and thermal, in each of the sub-regions 12. In this way, the host 39 is able to more precisely distribute the load within the region 100 where required, due to the more sensitive feedback provided by the localised load profiles.

Whilst the GES units are arranged in clusters for the purposes of communications, it is to be appreciated that the second distribution means 16, as well as the thermal distribution means 17, is able to interrelate the clusters 36 so as to allow for distribution of electrical or thermal energy between adjacent clusters. In addition, the energy network system can easily be replicated and extended to other regions as illustrated in Figure 3. Each new region can incorporate the same basic networked structure as the region described above. Further, the additional regions can be centrally controlled in the same manner back to the same host 39 and also a third distribution system 38 can be provided to allow one region to provide a link of energy and communication to a neighbouring region thereby effectively increasing the size of the regional cluster. Accordingly, the basic modular structure of the energy network system 10 allows easy expansion of the energy supply to new regions.

In the illustrated embodiment, the service utility retains ownership of each of the GES units 11 and provides the host function which controls the energy network system 10. Further, all billing information is able to be centrally coordinated by the host 39. In view of the embedded nature of the energy system 11, it is not necessary that the energy utility acquire large tracts of land to allow a region to be serviced. Instead, the land occupied by each of the generators 11 can merely be leased, through a reduction in rates, from the owners of the land on which the generators are located.

Accordingly, the present invention provides an energy system which is reliable, efficient and environmentally friendly. The system has minimum impact on the surrounding environment and, due to its embedded and modular nature, is able to be extended easily to additional regions.

It is to be appreciated that various alterations or additions may be made to the parts previously described without departing from the spirit or ambit of the present invention.

CLAIMS

1. A system for the generation and distribution of energy to a region, said region being formed of a plurality of sub-regions, and wherein the system includes a plurality of first energy distribution systems to distribute energy to a respective one of the sub-regions, a second energy distribution system to distribute energy to the first energy distribution systems, and a plurality of generators each associated with a respective one of the first distribution systems and the second distribution system so that each generator is able to supply energy both to its first distribution system and to the second distribution system.

2. An energy system according to claim 1, further including a plurality of local controllers associated with respective ones of the generators, each local controller operative to control the operation of each generator to which it is associated.

3. An energy system according to claim 2, wherein each generator is operative to be connected to its respective first distribution system via a first isolator, and wherein the operation of said first isolator is controlled by its associated local controller.

4. An energy system according to either claim 2 or 3, wherein the second distribution system is connectable to each first distribution system via a second isolator and wherein said operation of the second isolators are controlled by the local controllers.

5. An energy system according to any one of claims 2 to 4, further including a global controller operative to communicate with each of the local controllers, each local controller being configured to control the operation of its associated generator under instructions from said global controller, so that global controller is operative to control the energy supplied by each generator to its respective first distribution system and the second distribution system.

6. An energy system according to claim 5, wherein the system further includes first monitoring means which is operative to establish in real time the energy load demand in respective ones of the first distribution means and wherein the global controller is operative to control the generators in response to

the plurality of energy load demand profiles established by the first monitoring means.

7. An energy system according to claim 6, wherein respective ones of local controllers are operative to receive load data from the first monitoring means for a plurality of said first distribution systems and to transmit that load data to the global controller.

8. An energy system according to any one of claims 5 to 7, wherein each said local controller is able to communicate with other local controllers within said region, and wherein said local controller is operative to communicate with said global controller via a second local controller.

9. An energy system according to claim 8, wherein a plurality of the generators operate as a cluster with one of the local controllers associated with a generator in said cluster acting as a master controller for the cluster, the master controller being operative to communicate with said global controller to transmit data from the other local controllers associated with generators in said cluster and to instruct said other local controllers in response to instructions from the global controller.

10. An energy system according to claim 9, wherein a plurality of said local controllers are each able to operate as the master controller, and wherein the system includes means to change the designations of a said local controller as said master controller.

11. An energy system according to any preceding claim, wherein at least some of the generators have the facility to act as cogenerators that produces both electrical energy and thermal energy, and wherein each cogenerator is operative to supply electrical energy to each respective first energy distribution system, and the second distribution system, and supply thermal energy in its respective sub-region.

12. An energy system according to claim 11, further including a thermal distribution system that interconnects a plurality of sub-regions, and wherein the cogenerators are connected to the thermal distribution system to allow thermal energy from one cogenerator to be supplied to a plurality of sub-regions.

13. An energy system according to claim 12, wherein the thermal distribution system includes at least one reservoir operative to store thermal energy supplied by the generators.

14. An energy system according to any one of claims 11 to 13 when dependent on claim 6, further including second monitoring means that is operative to establish in real time the thermal load demand in each sub-region, and wherein the global controller is operative to control the generators in response to the plurality of thermal and electrical load demand profiles established by the first and second monitoring means.

15. An energy system according to claim 14, wherein respective ones of the local controllers are operative to receive the thermal load data from the second monitoring means for a plurality of said sub-regions, and transmit that load data to the global controller.

16. A method of generating and supplying energy to a region, said region being formed of a plurality of sub-regions, the method including the steps of:

(i) providing a plurality of generators in said region, the generators being operative to supply electrical energy to each sub-region,

(ii) obtaining load data in real time on the energy load demand in each of the sub-regions, and

(iii) controlling the operation of said generators based on the plurality of load demand profiles of the sub-regions.

17. A method according to claim 16, wherein each generator is associated with a particular sub-region and is operative to operate in stand-alone mode where that generator only supplies energy to its associated sub-region, and a network mode where that generator is connected in parallel to other said generators and is operative to supply energy to a plurality of sub-regions, the method further including the steps of operating the generator in stand-alone mode.

18. A method according to claim 16, wherein each generator is associated with a particular sub-region and is operative to operate in stand-alone mode where said generator only supplies energy to its associated sub-region, and a network mode where said generator is connected in parallel to said other

generators and is operative to supply energy to a plurality of sub-regions, the method further including the steps of operating the generators in network mode.

19. A method according to either claim 17 or 18, further including the step of operating some of the generators in stand-alone mode, whilst simultaneously operating other said generators in network mode.

20. A method according to any one of claims 16 to 19, wherein each generator has the facility to act as a co-generator that produces both electrical energy and the thermal energy to each of the sub-regions, the method including the steps of:

(i) obtaining thermal load data in real time on the energy load demand and the thermal energy load demand in each of the sub-regions, and

(ii) controlling the operating of said generators based on both the electrical demand profiles and the thermal load profiles of each of the sub-regions.

21. A method according to any one of claims 16 to 20, further including the steps of providing a plurality of local controllers, the local controllers being operative to control the operation of individual ones of said generators, and a global controller which is operative to communicate with each of the local controllers, the method further including the steps of operating said local controllers to control the operation of their associated generators under instructions of said global controller.

22. A method according to claim 21, further including the steps of transmitting load data from the respective sub-regions to said local controllers, and transmitting the load data received by said local controllers to said global controller.

23. A method of supplying and distributing energy to a region using an energy system according to any one of claims 1 to 15.

24. A system for the generation and distribution of energy to a region substantially as described herein with reference to the accompanying drawings.

25. A method of generating and distributing energy to a region substantially as herein described with reference to the accompanying drawings.

AMENDED SHEET (ARTICLE 19)

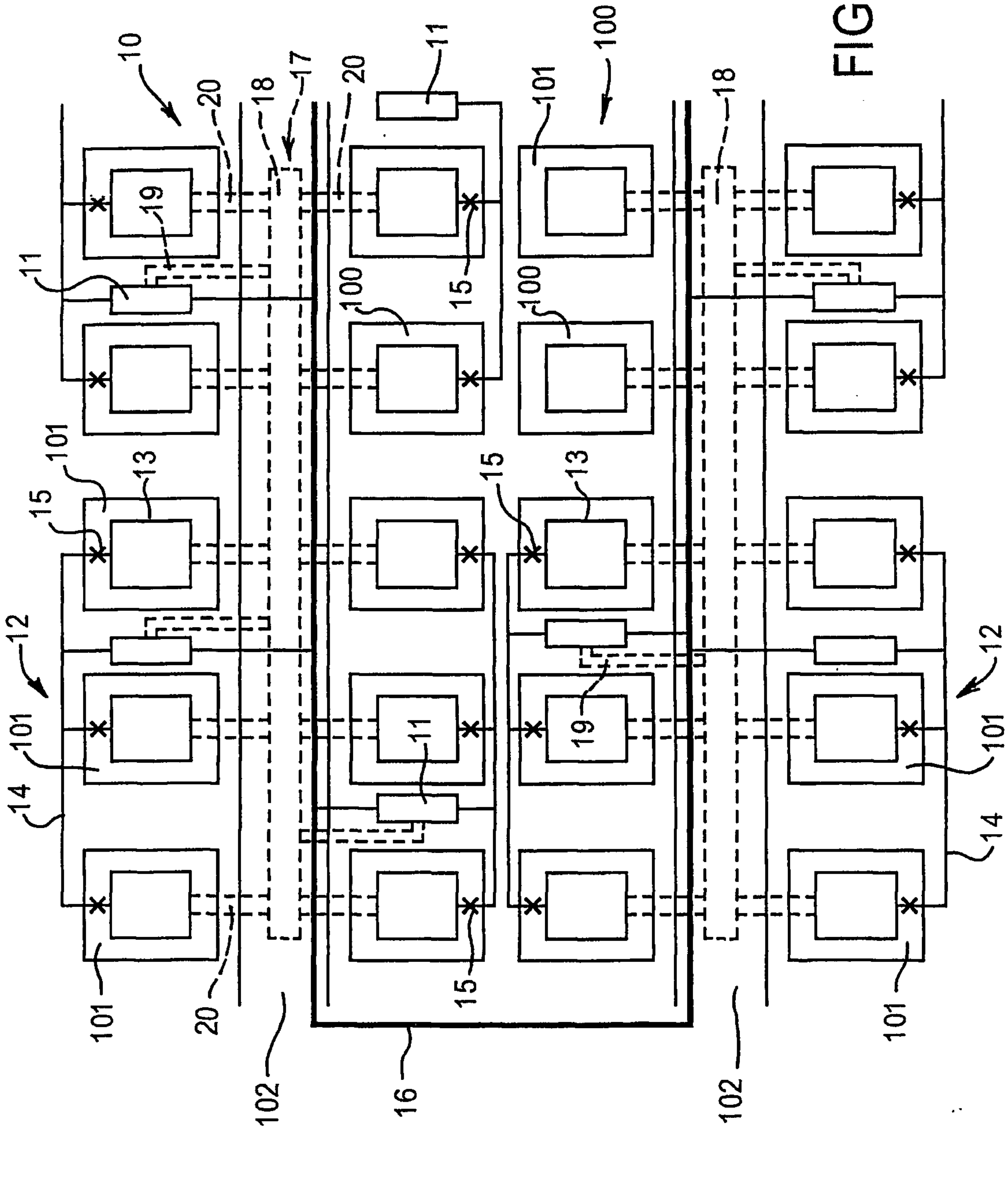

FIG 1

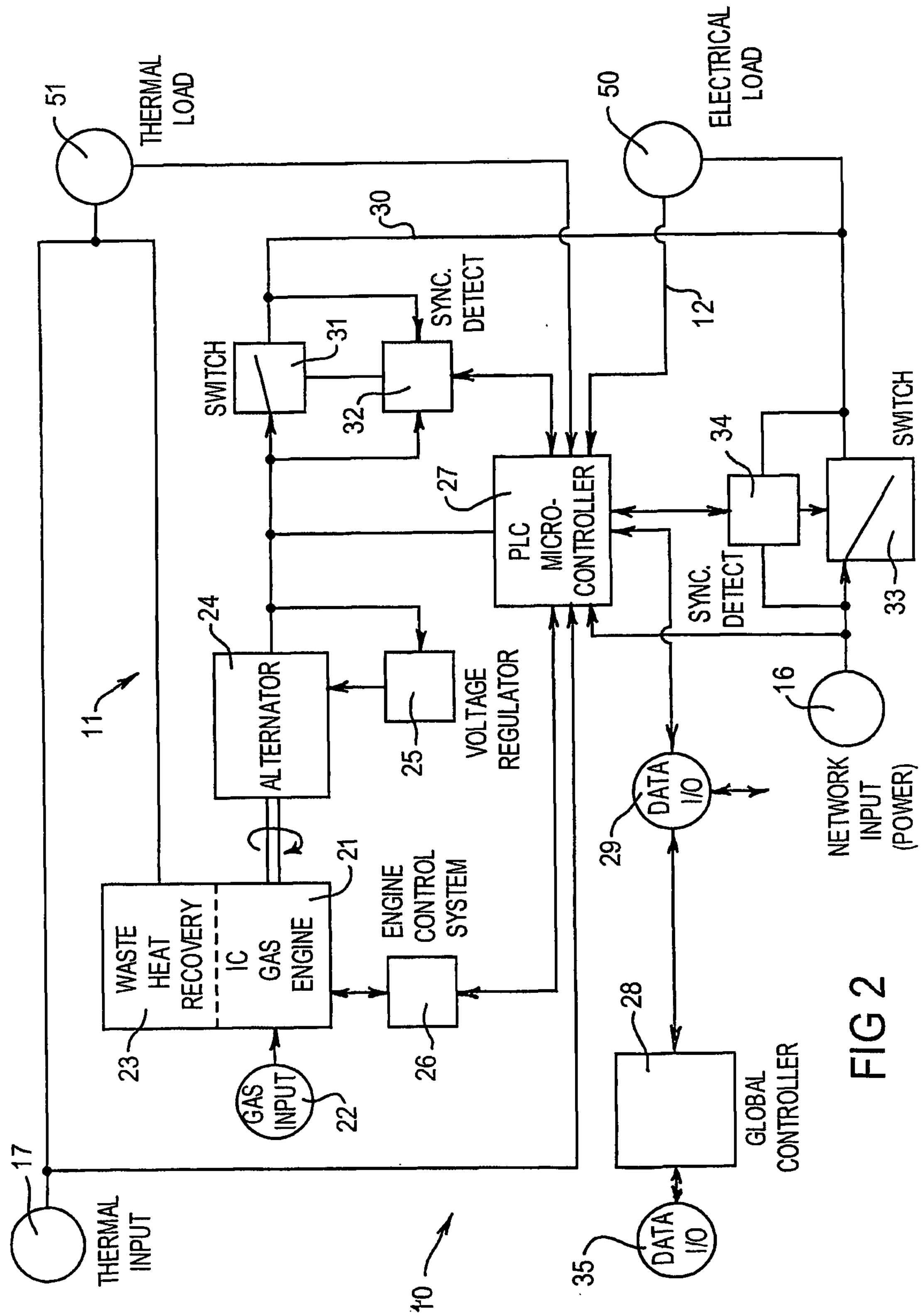
THERMAL LOAD
51
ELECTRICAL LOAD
50
30
SYNC. DETECT
SWITCH
31
32
12
27
PLC MICRO-CONTROLLER
34
SWITCH
SYNC. DETECT
33
24
ALTERNATOR
VOLTAGE REGULATOR
25
11
16
NETWORK INPUT (POWER)
DATA I/O
29
21
ENGINE CONTROL SYSTEM
WASTE HEAT RECOVERY
IC GAS ENGINE
23
GAS INPUT
22
26
28
GLOBAL CONTROLLER
17
THERMAL INPUT
DATA I/O
35
40

FIG 2

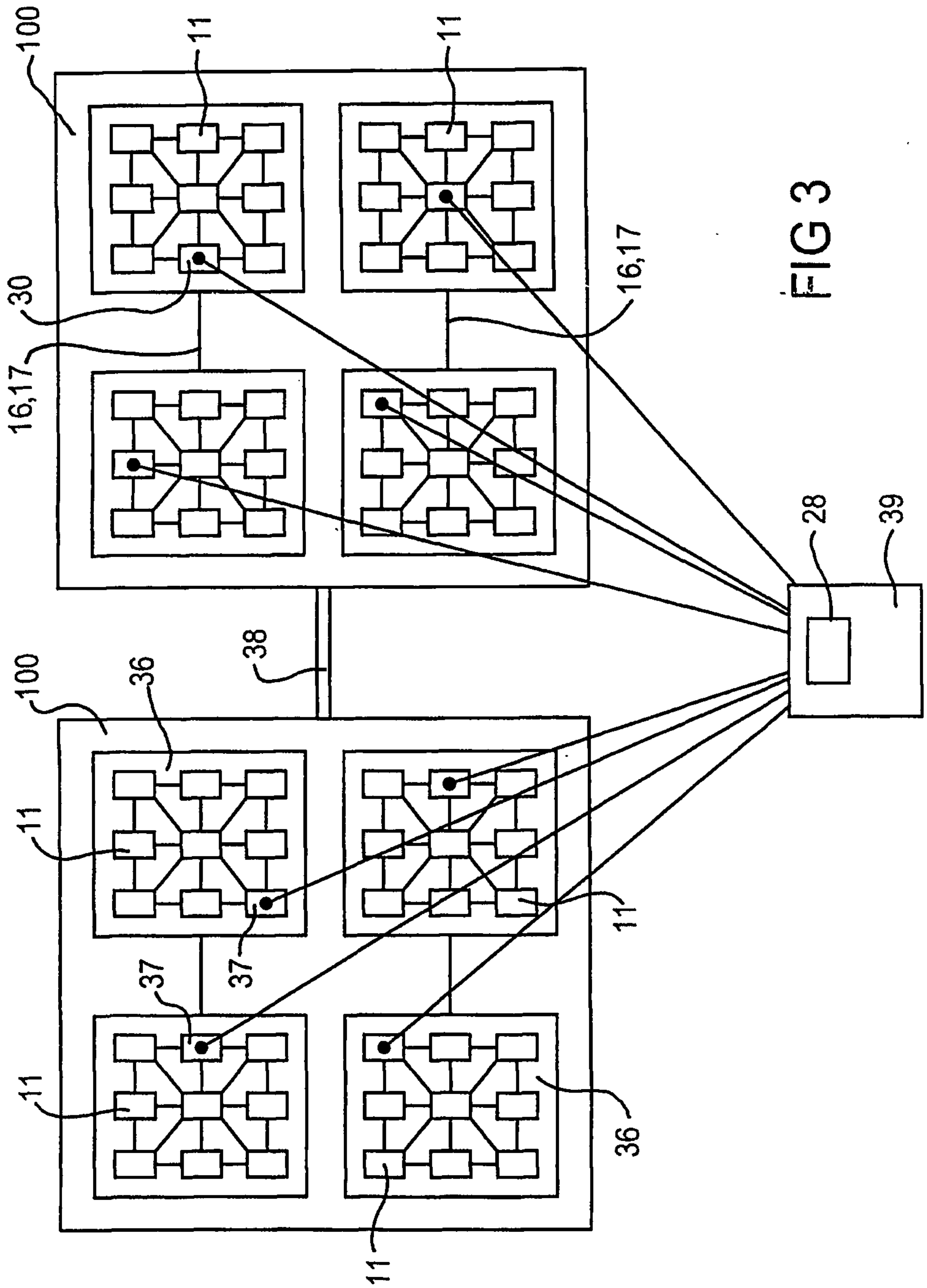

FIG 3

INTERNATIONAL SEARCH REPORT

International application No.
PCT/AU01/00167

A. CLASSIFICATION OF SUBJECT MATTER

Int. Cl. [7]: H02J 3/06

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

WPAT, IEEE, Internet (decentral+, generat+, region)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 6 026 349 (Heneman) 15 February 2000 Abstract, claims, Fig. 3	1,16
Y	US 4 527 017 (Ausiello) 2 July 1985 Whole document	1,16
A	"Industrial Applications for Micropower: A Market Assessment" for US Department of Energy and Oak Ridge National Laboratory by Resource Dynamics Corp. November 1999	1,16

[X] Further documents are listed in the continuation of Box C [X] See patent family annex

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier application or patent but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
19 April 2001	24 April 2001

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INTERNATIONAL SEARCH REPORT

International application No.
PCT/AU01/00167

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	WO 99/09631 (Nissin Electric Co. Ltd.) 25 February 1999 Abstract, figures	1,16
A	US 5 537 339 (Naganuma et al.) 16 July 1996 Whole document	1,6,16,20

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.
PCT/AU01/00167

This Annex lists the known "A" publication level patent family members relating to the patent documents cited in the above-mentioned international search report. The Australian Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

Patent Document Cited in Search Report		Patent Family Member					
US	6026349	NO	MEMBERS				
US	4527071	DE	3275917	DK	17/83	EP	83557
		IE	53629	IT	82/67006	IT	1212649
WO	99/09631	JP	11069664				
US	5537339	DE	69403378	EP	619537	JP	6251030

END OF ANNEX